Prognostic validity of 3-Minute Nutrition Screening (3-MinNS) in predicting length of hospital stay, readmission, cost of hospitalisation and mortality: a cohort study

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ABSTRACT

Background: It is important to identify patients who are at risk of malnutrition upon hospital admission as malnutrition results in poor outcomes such as longer length of hospital stay, readmission, hospitalisation cost and mortality. The aim of this study was to determine the prognostic validity of 3-Minute Nutrition Screening (3-MinNS) in predicting hospital outcomes in patients admitted to an acute tertiary hospital through a list of diagnosis-related groups (DRG). **Methods**: In this study, 818 adult patients were screened for risk of malnutrition using 3-MinNS within 24 hours of admission. Mortality data was collected from the National Registry with other hospitalisation outcomes retrieved from electronic hospital records. The results were adjusted for age, gender and ethnicity, and matched for DRG. **Results:** Patients identified to be at risk of malnutrition (37%) using 3-MinNS had significant positive association with longer length of hospital stay (6.6 ± 7.1 days vs. 4.5 ± 5.5 days, $p<0.001$), higher hospitalisation cost (S$4540 ± 7190 vs. S$3630 ± 4961, $p<0.001$) and increased mortality rate at 1 year (27.8% vs. 3.9%), 2 years (33.8% vs. 7.2%) and 3 years (39.1% vs. 10.5%); $p<0.001$ for all. **Conclusions:** The 3-MinNS is able to predict clinical outcomes and can be used to screen newly admitted patients for nutrition risk so that appropriate nutrition assessment and early nutritional intervention can be initiated.

Key words: Nutrition risk, 3-Minute Nutrition Screening (3-MinNS), Prognostic validity, Outcomes, Mortality.

INTRODUCTION

Malnutrition is prevalent in hospitalised patients and leads to poor clinical outcomes.[1-3] Many studies have shown strong association between malnutrition and longer length of hospital stay (LOS), increased mortality, higher rate of readmission and increased hospitalisation cost.[1-5] Therefore, it is important that all newly admitted patients are screened for malnutrition risk using a validated nutrition screening tool.[6]

Nutrition screening tools are designed to quickly and effectively identify people who are at risk of malnutrition or are already malnourished.[7,8] There are a number of validated tools available, including Malnutrition Universal Screening Tool (MUST), Malnutrition Screening Tool (MST), Mini Nutritional Assessment–Short Form (MNA-SF) and Nutrition Risk Screening-2002 (NRS-2002).[9-12] Each of these has been validated on predominantly Caucasian populations. The 3-Minute Nutrition Screening (3-MinNS) is an easy, fast and validated nutrition screening tool developed specifically to screen for nutrition risk in the Asian population.[13]

A systematic review had shown that there were limited nutrition screening tools that effectively and consistently provide good nutritional screening results and predict outcomes at the same time.[14]

The aim of this study was to evaluate the prognostic validity of 3-MinNS in predicting length of hospital stay, readmissions, hospitalisation cost and mortality in patients admitted to an acute tertiary hospital.

MATERIALS AND METHODS

Study participants and study design

This observational study was approved by National Healthcare Group Domain Specific Review Board in two separate time periods (DSRB-C/05/179 and DSRB-D/08/444). The first

ethical approval was sought and obtained to validate the 3-MinNS[13] and a second approval was obtained to track the outcomes of these patients subsequently. National University Hospital (NUH) is a 1032-bed acute-care tertiary hospital providing a range of speciality services. Over a 10-month period, newly admitted inpatients were consecutively screened for eligibility from a predetermined fixed sequence of 16 wards. A maximum of six consenting patients per day were recruited. Once all 16 wards had been covered, the sequence was repeated. Patients from the paediatrics ward were excluded as they used different nutrition screening indicators, and the psychiatric, intensive care and maternity units were excluded as per hospital request. Information on the hospital population was retrieved from NUH's Management Information Services.

3-Minute Nutrition Screening (3-MinNS) Tool

The 3-MinNS is a validated and easy-to-use nutrition screening tool that consists of three main components: 1) unintentional weight loss during the past six months; 2) nutritional intake in the previous week and 3) muscle wastage at the temporalis and clavicular areas.[13] Primary caregivers would score for the 'unintentional weight loss' and 'nutritional intake' components for uncommunicative patients. The tool consists of a "don't know" response for patients or caregivers who were unsure of any weight loss and to avoid any missing data in the weight loss column. A quantitative score of 0 to 3 was allocated to each criterion (3 = most severe).[13] A total score of 3 or more indicates patient is at risk of malnutrition. The nutrition screening scores were documented and made available to the healthcare professionals managing the patients in the wards.

Baseline nutrition parameters

Body weight and height were measured using the calibrated digital Seca weighing machine and stadiometer (Seca, Seca Deutschland, Germany). Mid-arm anthropometric assessment of tricep skinfold thickness (TST) and mid-arm circumference (MAC) was performed on the non-dominant arm using a calibrated Harpenden skinfold caliper (Harpenden, Baty International, England) and a measuring tape respectively. For the measurement of TST, the arm was extended and hanging relaxed. Measurements were taken midway between the point of the acromion and olecranon process on three consecutive occasions, and the average was calculated. Measurement of MAC was taken at the same site with the arm in an extended position. Mid-arm muscle circumference (MAMC) was calculated from the average measurements of MAC and TST using the equation: MAMC (cm) = MAC (cm) – 0.314 x TST (mm). Participants' serum albumin levels were documented if they had been done within the first two days of hospital admission.

Length of hospital stay (LOS), readmission, hospitalisation cost and mortality

Length of hospital stay, inpatient mortality and cost of hospitalisation were obtained from the hospital's electronic medical record. Hospitalisation cost consisted of the total cost of index admission prior to any government subsidy. Index admission was regarded as the admission when patients were enrolled into the study. Data for readmission were tracked prospectively for each participant at three different time points: 90 days, 6 months and 1 year from the date of discharge. The survival data (up to 3.5 years) were retrieved from the Singapore National Registry. Personal identifiable information was removed before the mortality data was returned to the principal investigator. Information on patient's DRG was obtained from NUH's Casemix Department retrospectively. The DRG is a system commonly used by many countries to categorise patients according to their diagnosis and procedures. Similar levels of disease complexity and treatment are usually grouped within each DRG.[15] Potential confounding factors arising from a patient's medical condition or disease, such as type and

complexity may affect the hospitalisation cost and outcome and could hence be controlled for using DRG. The LOS of study participants were compared with NUH's population and other Singapore public hospital patients with similar DRG. A comparison of hospitalisation costs between the study subjects and patients with similar DRG in NUH was also carried out.

Statistical analyses

The mean values for nutrition parameters were compared between patients at malnutrition risk and not at risk using two-sample T-test. Mixed model analysis with matching for DRG was used to determine differences in LOS and cost of hospitalisation between participants who were at risk of malnutrition and those who were not at risk. Poisson regression with matching for DRG was used to determine if malnutrition risk was associated with readmission and mortality. The result was presented as relative risk (RR) with 95% confidence interval (CI). A *p*-value of <0.05 indicates statistical significance. All variables were adjusted for age, ethnicity and gender. Statistical analyses were performed with the Statistical Package for the Social Sciences for Windows version 19.0 (SPSS Inc., Chicago, IL, USA).

RESULTS

A total of 818 subjects participated in the study, of which 37% (n=302) were identified to be at risk of malnutrition using 3-MinNS. The demographic profile of the study participants is presented in Table 1. There was no statistical difference in gender and ethnicity distribution between the study sample and hospital population. The study sample was older than the hospital population. The information on clinical specialties to which the participants had been admitted has been reported in a previous paper.[13]

Participants at risk of malnutrition were significantly older and had significantly lower body weight, body mass index, mid-arm anthropometrics and albumin levels compared to

participants who were not at risk of malnutrition (Table 2). Length of stay and cost of hospitalisation were significantly higher for participants identified as at risk of malnutrition than those not at risk, even after adjustment for ethnicity, age, gender and matched for DRG (Table 3). Comparing the mean difference in LOS between participants and NUH's patient population with similar DRG, those who were at risk of malnutrition had a significantly higher LOS. This significance was not lost after adjustment for confounding factors. Similarly, compared to all Singapore public hospitals, the mean difference in LOS was significantly longer in those who were at risk of malnutrition (Table 3).

Subjects with malnutrition risk had a significantly higher mean hospitalisation cost. These results were shown to be consistently significant before and after adjustment for confounding factors. When compared to the average cost of hospitalisation of study participants and NUH's population with similar DRG, the mean difference in hospitalisation cost for people who were at risk of malnutrition was shown to be six times higher than those who were not at risk of malnutrition, even after adjustment for confounding factors (Table 3).

3-Minute Nutrition Screening was shown to significantly predict mortality (log rank: $p<0.001$). The percentage of overall survival for participants at risk of malnutrition was 28.6% lower than those who were not at risk (Figure 1). Subjects identified to be at risk malnutrition using 3-MinNS had a higher mortality rate at 1, 2 and 3 years of discharge (Table 4). Results were shown to be consistent throughout these three years and the significance of the results persisted after adjusting for age, ethnicity and gender; and matched for DRG in data analysis. Unadjusted results for readmission within 90 days, 6 months and 1-year of index admission were shown to have a statistically positive association in participants who were at risk of malnutrition. However, after adjustment for confounding factors, the significance was lost.

DISCUSSION

This study is the first to examine prognostic validity of 3-MinNS in predicting outcomes. Patients at risk of malnutrition based on 3-MinNS have significantly higher mortality, longer length of hospital stay and higher cost of hospitalisation. Study participants at risk of malnutrition had a four-fold higher chance of mortality within 1 year compared to those not at risk after controlling for age, gender, ethnicity and disease using DRG. Mortality rates were statistically significant in both the unadjusted and adjusted results, showing that risk of malnutrition is an independent risk factor for 1-year, 2-year and 3-year mortality. A similar study that controlled for all three variables (age, gender and disease) found a significant two-fold increase in mortality in patients who were at risk of malnutrition using NRS-2002.[16] In studies that controlled for age and gender, Stratton et al[4] and Henderson et al[17] showed that geriatric patients identified as at high risk of malnutrition using MUST had 2-fold higher risks of mortality compared to those who were at low risk.

Patients who were at risk of malnutrition stayed in the hospital 1.5 times longer than those not at risk, and the results were significant even after controlling for age, gender and disease (DRG). One previous study also controlled for all three variables and found a similar result.[16] Sorensen et al[16] reported a 1.5 times longer LOS in patients who were at risk of malnutrition using NRS-2002 compared to those not at risk. Amaral et al[18] and Schiesser et al[19] also used NRS-2002 and found 1.7 and 2.6 times longer LOS in patients at risk of malnutrition respectively, however their results were only controlled for age and gender. Similarly, Stratton et al[4] controlled for age and gender, and found a 3.5 times longer LOS in geriatric patients at risk of malnutrition using MUST. Other studies associating nutrition risk with LOS mainly controlled for age or gender or did not control for any confounders.[20-22]

As for hospitalisation costs, patients at risk of malnutrition determined by 3-MinNS incurred 25% higher cost of hospitalisation. These results were significant even after

controlling for age, gender, ethnicity and matched for DRG. A cross sectional study conducted in Portugal found that patients at risk of malnutrition (using NRS-2002) incurred twice the mean cost of hospitalisation compared to those not at risk.[23] In that study, hospitalisation costs were estimated based on hospital LOS and DRG, [23] whereas our study used the exact hospitalisation costs. The higher cost for patients at risk of malnutrition was likely due to the higher LOS. A review paper by Norman et al[3] further supports the increased cost of hospitalisation in patients at risk of malnutrition, due in part to the increased length of stay in this group of patients.

The current study shows that even though patients at malnutrition risk were at about 1.4 times higher risk of readmission after 90 days and 6 months of discharge, this significance diminished after the results were controlled for age, gender, ethnicity and DRG. One Israeli study that controlled only for age found that elderly hip fracture patients who were at risk of malnutrition using MNA-SF had a 1.4 times higher chance of readmission 6 months after discharge.[24] Conversely, a study using MUST as the screening tool in geriatric patients did not show any significant increase in the readmission rate of patients at risk of malnutrition, after controlling for age and gender.[4] This led the authors to conclude that social factors may affect the readmission rate of patients.

Previous studies on the relative validity of 3-MinNS showed good sensitivity and specificity of the tool.[13,25] This study provides evidence-based information on the prognostic validity of 3-MinNS in the adult hospitalised population. The overall result of this present study shows that 3-MinNS is able to predict hospitalisation outcomes such as length of hospital stay, cost of hospitalisation, readmission and mortality. It is therefore even more important that patients identified to be at risk of malnutrition are referred to the dietitians for a thorough nutrition assessment and appropriate nutritional intervention.[13,26]

The strengths of this study include consecutive sampling methodology to achieve a large pool of newly admitted patients, representative of the hospital population.Additional strengths of this study include the prospective tracking of clinical outcomes and the use of exact cost of hospitalisation. The retrieval of mortality data from the National Registry ensured accuracy of the data to ensure information is captured on subjects who have passed away after being discharged from the hospital. This is the only study to track mortality data for up to three years to determine the prognostic validity of a nutrition screening tool. A further strength is that results were simultaneously controlled for age, gender, ethnicity and disease, thus reducing confounding factors. This has rarely been done in other studies.

A limitation of this study was our inability to determine the number of patients who were subsequently referred for dietetic management after being screened to be at risk, and whether these patients had improved outcomes with treatment, as these were beyond the scope of the study. At the time of the study in 2006, referrals to the dietitian were solely by referrals from the doctors and many patients who were at risk of malnutrition were not routinely referred to a dietitian. With the supporting outcomes data after the completion of this study in 2010, we have successfully put in place a comprehensive system to ensure patients at risk of malnutrition are referred for nutrition care during hospitalisation and are followed up closely after discharge.[26,27] These efforts have resulted in improved nutrition status, functional outcomes and quality of life for patients.[26]

CONCLUSION

The 3-Minute Nutrition Screening has good prognostic value in predicting length of hospital stay, mortality and cost of hospitalisation of patients. It can be used to screen newly hospitalised patients for nutrition risk so that early detection and appropriate intervention can be initiated.

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TABLES

Table 1. Baseline characteristics of study participants (n=818) and the hospital population (n=21,348)

	Gender (%)		Ethnicity (%)				Age (years) (mean ± SD)
	Female	Male	Chinese	Indian	Malay	Others	
Study Sample (n=818)	41	59	62	11	20	7	51.9 ± 15.4
Hospital Population (n=21,348)	44	56	60	13	18	9	49.3 ± 15.9
***p*-value[§]**	0.24		0.05				<0.001*

n = number; SD = standard deviation
[§]Statistical analysis is by Chi-square test for gender and ethnicity and 2-Sample T-test for age
*Statistically significant

Table 2. Comparisons of age and baseline nutrition parameters between study participants who were at malnutrition risk and not at malnutrition risk as determined by 3-MinNS

Baseline parameter	Number of subjects	3-MinNS		*p*-value[§]
		Not at risk (Mean ± SD)	At risk (Mean ± SD)	
Age (years)	818	49. 4 ± 15.4	55.9 ± 14.3	*p < 0.001**
Weight (kg)	818	67.8 ± 14.3	56.7 ± 13.9	*p < 0.001**
Body Mass Index (kg/m^2)	734[¶]	25.5 ± 5.1	21. 9 ± 4.8	*p < 0.001**
Tricep skinfold thickness (mm)	818	16.3 ± 7.1	12.3 ± 6.2	*p < 0.001**
Mid arm circumference (cm)	818	30.5 ± 4.3	26.7 ± 4.8	*p < 0.001**
Mid-arm muscle circumference (cm)	818	25.4 ± 3.4	22.8 ± 3.7	*p < 0.001**
Albumin (g/L)	375[†]	38.8 ± 6.2	35.8 ± 6.3	*p < 0.001**

3-MinNS = 3-Minute Nutrition Screening tool; SD = standard deviation
[§]Statistical analysis is by 2-Sample T-test
*Statistically significant
[¶] Excluding missing data due to inability to obtain height of participants to calculate Body Mass Index
[†] Excluding missing data for albumin levels

Table 3. Comparisons of the length of hospital stay and cost of hospitalisation between study participants who were at malnutrition risk and not at malnutrition risk as determined by 3-MinNS (n=818)

Outcome	3-MinNS		Unadjusted *p*-value[†]	Adjusted *p*-value[‡]
	Not at risk (n =516)	At risk (n =302)		
Length of hospital stay (days)				
• Mean ± SD	4.5 ± 5.5	6.6 ± 7.1	*p*<0.001*	*p*<0.001*
• Median (range)	3 (1–63)	4 (1–59)		
Mean difference in length of hospital stay for study subjects compared to length of hospital stay for NUH patients with similar DRG (days)				
• Mean ± SD	-0.2 ± 4.3	1.6 ± 6.3	*p*<0.001*	*p*<0.001*
Mean difference in length of hospital stay for study subjects compared to average length of hospital stay for Singapore public hospitals' patients with similar DRG (days)				
• Mean ± SD	-0.8 ± 4.5	0.9 ± 6.5	*p*<0.001*	*p*<0.001*
Cost of hospitalisation (Singapore dollars, $)				
• Mean ± SD	3630 ± 4961	4540 ± 7190	*p*=0.033*	*p*=0.037*
• Median (range)	1933 (178– 63494)	2638 (297–70471)		
Mean difference in cost of hospitalisation for study subjects compared to average cost of hospitalisation for NUH patients with similar DRG (Singapore dollars, $)				
• Mean ± SD	263 ± 3254	1576 ± 5852	*p*<0.001*	*p*<0.001*

3-MinNS = 3-Minute Nutrition Screening tool; n = number; SD = standard deviation; NUH = National University Hospital; DRG = Diagnosis-related groups

[†,‡]Statistical analysis is by 2 Sample T-test for unadjusted results and Linear Regression for adjusted results

[†] Results were not adjusted

[‡] Results were adjusted for age, gender and ethnicity; and matched for diagnosis-related groups

*Statistically significant

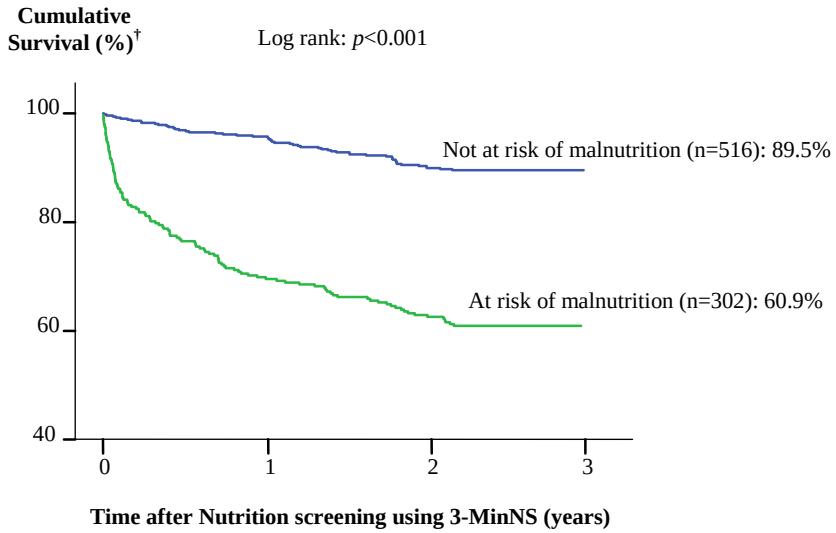
Table 4. Comparison of mortality and readmission rates between study participants at malnutrition risk and not at malnutrition risk using 3-MinNS (n=818)

Outcome	3-MinNS		Unadjusted[†]			Adjusted[‡]		
	Not at risk (n =516)	**At risk (n =302)**	RR	95% CI	*p*-value	RR	95% CI	*p*-value
Inpatient mortality • n (%)	0 (0)	12 (4)	NA[§]	-	*p*<0.001*	NA[§]	-	*p*<0.001*
1-year cumulative mortality • n (%)	20 (3.9)	84 (27.8)	7.19	4.50, 11.5	*p*<0.001*	4.33	2.23, 8.40	*p*<0.001*
2-year cumulative mortality • n (%)	37 (7.2)	102 (33.8)	4.72	3.32, 6.67	*p*<0.001*	2.55	1.58, 4.14	*p*<0.001*
3-year cumulative mortality • n (%)	54 (10.5)	118 (39.1)	3.73	2.79, 4.97	*p*<0.001*	2.40	1.58, 3.65	*p*<0.001*
Readmission within 90 days of index admission • n (%)	120 (23.3)	100 (33.1)	1.42	1.14, 1.78	*p*<0.001*	1.32	0.95, 1.85	*p*=0.10
Readmission within 6 months of index admission • n (%)	164 (31.8)	135 (44.7)	1.41	1.18, 1.68	*p*<0.001*	1.34	0.99, 1.79	*p*=0.05
Readmission within 1 year of index admission • n **(%)**	207 (40.1)	159 (52.6)	1.31	1.13, 1.52	*p*<0.001*	1.23	0.94, 1.59	*p*=0.13

3-MinNS = 3–Minute Nutrition Screening tool; n = number; RR = Relative risk; 95% CI = 95% Confidence Interval
[†,‡] Statistical analysis is by Poisson Regression
[†] Results were not adjusted
[‡] Results were adjusted for age, gender and ethnicity; and matched for diagnosis-related groups
[§] Unable to calculate RR due to no inpatient death for all patients who were not at risk of malnutrition as determined by 3-MinNS
*Statistically significant

FIGURES

Figure 1. Comparison of overall survival in study participants at risk and not at risk of malnutrition (n=818)[§]



n= number; 3-MinNS = 3-Minute Nutrition Screening tool
† Survival and mortality data retrieved from Singapore National Registry
§ Statistical analysis is by Kaplan Meier analysis with log-ranked test